EMERGENCY OPERATIONS SYSTEMS DEVELOPMENT

REMEDIAL MOVEMENT

SUMMARY OF PHASE 1 REPORT

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PREFACE

This booklet is a summary of one of 11 preliminary reports on the Emergency Operations Systems Development (EOSD) project of the Office of Civil Defense.

The project is being conducted by Stanford Research Institute, under OCD Contract PS-65-62, to develop guidance for emergency operations systems which are integrated with and capable of supporting the shelter-based civil defense programs.

The 11 tasks in the EOSD project are:

1. Warning
2. Shelter management
3. Movement to shelter
4. Rescue
5. Law and order
6. Remedial movement
7. Local communications
8. Radiological defense
9. Public works engineering
10. Emergency welfare services
11. Emergency medical services

This summary covers Phase I of the Remedial Movement task, which analyzed and evaluated existing data. The complete Phase I report has been submitted to the Office of Civil Defense. Phase II of the project will include development of guidance and training materials, and a final report.

The findings, conclusions and recommendations of this study should not be construed as OCD policy, guidance or instructions for action by civil defense or other government officials.

CONTENTS

I INTRODUCTION

Phase I of the Remedial Movement task in the Emergency Operations Systems Development (EOSD) program describes several potential emergencies affecting survival of people in shelter and, through analysis and evaluation, suggests methods by which these contingencies can be reduced through the planned and controlled movement of the occupants

The objectives of the Remedial Movement task are:

1. To determine the nature and size of the problem.

2. To recommend means of developing or improving capability for the movement of occupants when it is essential to do so.

The study was limited to situations resulting from nuclear attack. Movement decisions and control procedures were considered only for groups of 10 or more in a shelter where there would be a leader. The effects of nuclear detonations during remedial movement are not fully considered.

The task components accomplished during the work were: a review and analysis of research and other literature on situations which might make remedial movement necessary, and the procedures and decision-making criteria that could be used in evaluating movement alternatives; analysis of the effects of various attack environments on three communities to identify the types and extent of movement problems; definition of factors involved in decision-making, and requirements for successful moves; synthesis of alternative systems to fulfill decision-making and control requirements; analysis of problem magnitude and effectiveness factors; definition of a recommended system and implications of its implementation; and a preliminary examination of a technique for predicting fallout dose for shelter inhabitants.

The Phase I study was performed by the Research Triangle Institute of Durham, North Carolina, under contract with Stanford Research Institute. This summary was prepared by Stanford Research Institute and published in final form by Media Planning and Production, Inc.

II SUMMARY

The Remedial Movement study has led to the following conclusions and recommendations:

General

In the event of nuclear attack, persons in some shelters may encounter structural collapse, fire, flood, excessive radiation levels, or other in-shelter environmental factors that necessitate movement to a safer location.

The decision to move elsewhere depends upon the situation at the primary shelter, the effectiveness of on-site countermeasures, and the availability and accuracy of information on dangers en route to and at the proposed secondary site. Such decisions often will have to be made on the basis of estimates rather than facts. However, outside assistance and information will increase the probability of a correct decision. Therefore, an important requirement exists for communications between the shelter and the Emergency Operations Center (EOC), or as a minimum a communications capability to receive messages at the shelter.

An accurate assessment of the situation at the primary shelter is necessary before a decision can be made as to whether it can be controlled adequately within the shelter or whether a movement to another area or shelter is advisable.

If this assessment indicates the desirability of movement, officials must then determine the location and availability of secondary shelter, the fire and radiation situation, debris and traffic along various routes, and the availability of transportation. If possible, information concerning these factors and other assistance in planning and executing the move should be made available by the EOC through two-way communications between shelters and the EOC.

Analyses of Whatcom County, Washington; Des Moines, Iowa; and the Atlanta, Georgia CSP areas, under various attack conditions, indicate that post-attack movement of shelter occupants could save the lives of many persons, particularly where there was fire but no fallout. It was also determined that accurate information on fallout intensity and dose accumulation is required to calculate "go-time" (best time for remedial movement in a fallout environment) or to evaluate alternative protective actions for particular locations.

Alternative Programs

Several alternatives for improving movement capability have been defined, and associated costs have been estimated. Providing a handbook and amending the Federal Civil Defense Guide would require relatively small expenditures. Other more expensive and time-consuming possibilities include: preattack analysis of individual shelters for fire and structural vulnerability; in-shelter aids for identifying hazards; and training EOC personnel and shelter managers in moving shelter occupants.

Effectiveness of Inter-shelter Movement

Inter-shelter movement can be a factor in the survival of approximately 15 per cent of the population after a nationwide attack, and correct decisions will be increased by the availability of a well-structured system.

The effectiveness of remedial movement relative to other civil defense systems requires further analysis of their interrelationships, but it seems apparent that its effectiveness will depend particularly on the information and communications systems for emergency operations.

Recommendations

Implementation of a remedial movement program would include preparation and distribution of a handbook for use by EOC staffs; preparation and distribution of a chart and guidance for use of shelter managers; equipping shelters with kits to detect dangerous situations and to control movement; and training of EOC personnel in movement decision-making. Such a program would require an estimated 5 years at a cost of $2 million. Further investigation is recommended into methods of evaluating radiation and fire situations, and into an analysis of the relationship between inter-shelter movement and other Civil Defense systems. It is concluded that system implementation would cause no special problems of public involvement.

III POTENTIALLY DANGEROUS SHELTER SITUATIONS

The potential situations which singly or in combination might require movement are fire, flood, radiation, building collapse, and unfavorable in-shelter environment.

Fire

In evaluating the threat from fires, most occupants of shelter areas in underground portions of shelter facilities could survive if burning rubble does not fall on the shelter to destroy or overheat it, and if lethal amounts of carbon monoxide are kept out of the shelter by effective sealing. Under these circumstances, with 80 cubic feet of shelter space per person, shelter occupants could be expected to survive the oxygen depletion and carbon dioxide buildup in the shelter for approximately five hours.

Effective sealing of the shelter against carbon monoxide is required since extremely small concentrations of this gas (0.1 per cent in air at one atmosphere) can result in death within two hours; concentrations of one per cent can cause collapse and danger of death within minutes. In the firestorm areas of Hamburg, Germany, during World War II, however, 85 per cent of the people--and nearly all of the 50,000 persons in bunkers and other non-basement shelters--survived, primarily as a result of effective sealing of the shelters.

Flood

Flooding may be caused by ruptured water lines, sewer lines, or utility piping; by the collapse of dams; or by the diversion or damming of streams. If water mains can be repaired, or if the flow can be stopped at valves, local flooding may be controlled. Shelter managers should be able to locate shutoff valves. Widespread flooding may require movement as the only feasible survival measure. Shelter managers should be supplied with topographic maps of the surrounding area showing the shelter elevation and high water level.

Radiation

A decision for or against inter-shelter movement should be based on knowledge of the biological effects of different radiation dose levels, observation of the in-shelter radiation level, and the application of general guidelines to the observed radiation dose rates in a shelter. Probable future dose rates may be computed and made available to the decision maker

by radiological defense analysts at an EOC. In marginal cases, the shelter manager should consider actions other than movement, to reduce the radiation danger.

Structural Damage

Although structural damage can affect the habitability of the shelter as well as its ability to protect against fallout, the principal hazard faced by occupants is the danger of collapse. This danger would be increased by fire, heavy winds or snow, collapse of surrounding structures, and additional explosions.

Guidelines for action in damaged structures should be developed to indicate whether the structure is safe, can be made safe for further occupancy, or whether it should be evacuated, if possible. "Go/no-go" type decision tables keyed to building types, and simple methods for determining structural deformation should be developed and placed in each shelter. The installation of shoring soon after the damage is incurred may make the shelter usable.

Other In-Shelter Hazards

The principal in-shelter environmental condition that could require movement is overheating, although hunger, thirst, disease, or injury may contribute to the necessity for relocation.

Overheating can result from adjacent fires or the weather, but is usually caused by the lack of ventilation to carry away body heat. The effect of high temperature on individuals varies, but generally, unless the effective* temperature is kept from rising above certain levels, shelterees can collapse and die within a matter of hours. The primary countermeasure is adequate ventilation, but curtailment of activity in the shelter and the effective treatment of heatstroke patients can reduce the hazard.

Crowding contributes to excessive temperature, but should not otherwise be a significant hazard for limited periods of time, except in a relatively small fraction of cases.

* Effective temperature is an index of the degree of warmth felt by the body in response to various combinations of temperature, humidity and air velocity.

Lack of food or water will probably not by themselves be major reasons for movement. Lack of food is not expected to be a critical problem, because people can survive without it until supplies can be moved into the shelters. Water would be needed, however, within about one week.

Disease and injury are not significant factors in decisions to move, particularly if a person with some medical training is in the shelter. Conditions might require movement of patients to a medical facility where they can receive treatment not available in the shelter.

IV PRINCIPAL ELEMENTS INVOLVED IN REMEDIAL MOVEMENT

The principal elements determining the practicability of movement are selection of a relocation site and a route to it, the availability of vehicles, and the need for and the capability of taking other actions necessary to facilitate the movement, e.g., debris clearance.

Identification of Relocation Site

The relocation site should provide protection from existing and potential dangers. If fire is a factor, large open areas such as parks or golf courses may provide protection; if fallout is involved, a shelter with a greater protection factor or in an area of little or no radiation should be chosen. The probability of proper site selection will be increased if EOCs can collect, evaluate, and communicate information. If communication with an EOC is not possible, the Emergency Broadcasting System (EBS) should be monitored for information; lacking that resource, properly equipped scouts may be deployed to locate an adequate site. However, the likelihood of carrying out an effective movement without information and assistance from the EOC is seriously diminished.

Selection of Routes

Route selection depends upon the dangers en route, movement obstacles, and traffic between the primary shelter and the new site. The degree, location and direction of spread of fire, radiation and other possible hazards will be principal considerations. Assistance from the EOC will be desirable in route selection. In any case, receipt of information in the shelter about dangers along major routes is mandatory. If communications from the outside are not available, then scouts must be used.

While fire and radiation may not be significant factors along a given route, obstacles and traffic conditions must still be considered. Debris and rubble may obstruct passage, or abandoned automobiles may clog streets. These factors may retard movement, thereby increasing the exposure to other dangers such as mass fires and radiation. Obstacles may slow vehicles or preclude their use, and may affect the rate of movement of people on foot.

Actions Facilitating Movement

Vehicles should be used in the movement if they are available and can overcome debris and other obstacles. They provide a nominal level of shielding, and they may be loaded with supplies so as to increase the

shielding capability. They will also shorten transit time. Automobiles near shelters and in used car lots would be used if not too severely damaged by blast or fire, and if ignition keys are left in them or the ignition can be "jumped". Buses, trains, and trucks may also be available in some areas.

Movement plans should be completed and explained to shelterees before leaving the shelter. Movement on foot should be organized so that the shelterees move in groups to the selected site in the shortest possible time. If there is fallout, groups should be as compact as possible for protection by mutual shielding. Groups should be made up of persons with similar degrees of mobility, and the faster groups should proceed first.

If shelter officials have no outside assistance in planning, route reconnaissance is necessary. If there is no fallout, traffic guides and controllers may be used to facilitate movement. Early groups can clear pathways through debris for the slower and less able-bodied people.

If information and assistance is available from EOC, arrangements may be made to have police and volunteers control traffic, and for public works crews to clear roads of debris. An EOC may also establish staging areas or provide transportation at central points to move persons from areas of high or moderate hazard to sites at which there is little or no hazard. More effective use of available transportation may also result.

V DECISION-MAKING IN REMEDIAL MOVEMENT

Decisions for or against movement, the selection of the secondary site, and the time and route of movement should be made by the EOC. When the shelter manager cannot communicate with the EOC, he will have to base his decision to move upon the best information available to him. In any case, when danger threatens shelterees, the major questions are:

1. What is the risk if no action is taken?

2. What on-site actions can be taken to reduce the risk?

3. What are the movement alternatives and their probably effects?

Evaluating On-Site Measures

While the feasibility of on-site measures--such as sealing the shelter against carbon monoxide, relocating in-shelter material to shield against radiation, and hasty decontamination techniques--can be determined, their effectiveness cannot always be predicted. However, they will generally improve the situation, while a poorly planned and executed movement would worsen it.

Evaluating Movement Conditions

In Fallout

The information required for a decision on movement in the presence of fallout includes:

1. The radiological situation at the primary shelter.

2. The location and characteristics of the new site, including the space available, its protection factor (PF) and fire vulnerability, radiological and fire conditions in the area, and the availability of water and other stocks.

3. The movement times for each alternative route, which will be determined by the length and condition of the routes, the availability of vehicles and movement control measures, and the probable rate of travel.

4. Route hazards at the anticipated time of movement.

5. Estimated radiation dose during the move.

The degree of protection afforded by the structure and loading of vehicles, and mutual shielding during the move cannot be accurately determined in advance. Thus, even if time and duration of the move are known, the estimated radiation dose may vary considerably.

Route reconnaissance will result in better estimates, but actual movement time, route, dose rate, and PF will differ from that of the scout, and the estimated dose will only be an approximation.

Uncertainty about the radiation dose, travel time, and new site environment may require basing the decision on incomplete information, or delaying it pending better information. Where radiation levels and PF information are available, nomographs may be used to determine doses in various environments and the last departure time based on fallout from one weapon. A method of determining the dose from more than one weapon is also available.

In the Absence of Fallout

In the absence of fallout, the advisability of movement will depend on the existence or likelihood of other hazards. The availability and condition of the new site must be determined. The more information available on alternative sites, the more effective the movement decision can be. However, if the situation at the primary shelter is urgent, there might not be sufficient time to collect all the desirable information.

Examples of Remedial Movement Decision-Making

Here are two examples of movement decisions under specified conditions:

Example A. An EOC determines, from information provided by the shelter, that over a two-week period 900 people will receive radiation doses causing approximately 50% casualties and severe illness among survivors. Decontamination and makeshift shielding are not feasible, and relocation is indicated. The dose at the shelter prior to movement, the dose during movement, the dose at a new site during the balance of a two-week period, and the resultant total two-week dose are computed at the EOC. This total projected radiation dose is found to be within tolerable limits, and an optimum departure time is established. Another shelter is selected by the EOC, which arranges for necessary supplies. A route is open, and vehicles are available

at the optimum departure time. The EOC then provides the first shelter with movement instructions, and the movement begins at the proper time.

Example B. No fallout is present, but an EBS broadcast indicates that it will arrive in four to five hours. There are fires close to the shelter, but the shelter manager estimates that the fire resistance of the shelter will give the occupants a better than even chance to survive them. Water trapped in the building could be used to fight the fire, but this would reduce the water supply to a level sufficient for only a few days. There are shelters a few miles away with the same PF, and they are in open areas where the fire hazard is reduced. Access routes, however, pass through areas of group fires, and there is some danger of a conflagration. Conditions preclude the use of vehicles.

The decision-maker must choose quickly between two courses of action or decrease the probability of either being effective. He may stay in the first shelter, attempt to reduce the effects of the fire, and try to make the water last as long as possible; or he may risk movement by foot through hazardous fire areas before the fallout arrives. Since movement to a new location would be only marginally effective in improving chances for survival, the shelter manager would probably decide against movement.

Information Requirements

Information on secondary sites, fires and radiation hazards, route conditions, and resources for movement can best be provided through two-way communication with an EOC. If two-way communication does not exist, periodic broadcasts of this information will reduce some of the uncertainty in arriving at decisions.

Post-Shelter Movement Decisions

Even when immediate threats are reduced, movement may still be desirable due to increasing residual radiation levels. Many of the factors that apply under hazardous conditions will also apply to post-shelter movement, but more time will be available for planning, assistance, and execution.

VI CASE STUDIES OF REMEDIAL MOVEMENT

Three geographic areas being surveyed under the EOSD project were analyzed under different hypothetical attacks to determine situations for which movement might be required, and actions to implement movement.

The areas studied were Whatcom County, Washington; Des Moines, Iowa; and Atlanta, Georgia. Whatcom County has a population of about 72,000, concentrated in Bellingham. There are good county roads. Almost all of the identified shelter spaces are in Bellingham, and the CSP provides for sheltering 26,000 persons by night and 30,000 by day.

Des Moines has a population of about 265,000. Small rivers passing through the city's center require numerous bridges. Rail yards south of town interrupt street patterns. There are more than enough shelter spaces for the entire population but more than half of these spaces are located in a small downtown area.

Atlanta has a peak population of 1,264,977. The city is in rolling country with several rail lines and highways entering the city. Only 597,669 spaces are considered utilized by the Community Shelter Plan (CSP).

The Attack Situations

Three hypothetical attack situations were designated: (1) Optimum Aim Point (OAP); (2) Civilian Logistics (CIVLOG); and (3) Medium Counterforce (MC). Special attack situations also were provided.

The summary effects of the simulated attacks are shown in Table 1.

Situations Requiring Corrective Actions

The dangers analyzed were fire, flood, radiation, and building damage. Mass fires were assumed for all areas receiving greater than 5 psi overpressures, and group fires for all areas receiving 2-5 psi overpressures. Shelter PFs were considered in determining the radiation hazard, and the type of shelter structure was considered in estimating building damage. Flooding was studied where debris caused damming of local waterways. Utility line breaks, ventilation, and disease and injury were not included in the studies, nor were overcrowding, hunger and thirst.

TABLE 1

Summary Effects of Simulated Attacks on Three Areas

Study Area	OAP	CIVLOG	MC	Special
Whatcom County, Washington	No direct effects. Little or no fallout.	No direct effects. Little or no fallout.	3.5 MT airburst, 5 miles from Bellingham. Fires destroy city but little or no fallout occurs.	5 MT surface burst 100 miles upwind. Low level fallout.
Des Moines, Iowa, and metropolitan area.	10 MT surface burst on CBD*. Local fallout and heavy damage.	No direct effects. Fallout arrival occurred in 6 - 8 hours.	No direct Effects. Moderate fallout levels, with arrival in 6 - 8 hours.	1 MT surface burst on CBD. 3 MT surface burst on CBD. Not analyzed.
Atlanta, Georgia, and seven county area.	10 MT surface burst on CBD. Local fallout, heavy damage, and added fallout in 10 hours.	No direct effects. Fallout arrival occurred in 9 hours.	3.5 MT air burst on Marietta. Some fire and low level fallout on north edge of city.	None considered.

*Central Business District

Whatcom County

People in shelter under the OAP, CIVLOG, and special attack situations would not have required inter-shelter movement. The MC attack badly damaged almost all shelters in Bellingham; most of the city would have had serious fires within one-half hour, and almost all of the built-up area of the city would have been destroyed by fire within eight hours. There was no appreciable fallout, but among the 27,000 survivors of the blast, 25,000 would have required immediate movement to escape the threat of fire, and the rest would have had to move within hours.

Most movement would have been on foot for a distance of not more than 1-1/2 miles along railroads and wide streets. Debris would have kept special vehicles from moving in downtown streets; thus, the injured would have had to be carried out on foot. It might have been impossible to save some of the injured for this reason. Prompt movement to escape the fire hazard in Bellingham could have saved the lives of 1300 to 5400 persons, assuming that 5-20 percent of the population at hazard in mass fires would have actually succumbed.

Des Moines

Des Moines sustained fallout only under the MC and CIVLOG attacks, and since adequate shelters were available, few moves would have been required. The OAP attack resulted in the detonation of a ten-megaton weapon on the Central Business District and thus exceeded the direct effects of the special attacks. The OAP attack left only 10,300 people surviving, and almost half of their shelters had been destroyed. Fire was likely after one-half hour, and the city would probably have burned almost completely within seven or eight hours. Radiation intensity at six minutes after detonation exceeded 1,000 r/hour in some areas, and exposure for 15 minutes would have been fatal. In only a few locations were the radiation levels appreciably lower. The combination of early fire, early heavy fallout, and structural damage to shelters made movement decisions critical.

Feasible movements in Des Moines under the OAP attack differed drastically with location. Many survivors could have avoided fire and fallout by quickly moving out of town along freeways to the south, east and west by vehicle, and along railroads and streams on foot. Some persons in surviving shelters could have stayed in those shelters and fought the fire. A few people surviving in shelters which were destroyed could have moved to shelters in safe areas or to the outskirts of the city.

Atlanta

The CIVLOG and MC attacks on Atlanta both produced appreciable fallout levels which required shelter but little or no movement. In the OAP attack, the blast destroyed most of the shelters and caused such debris that survivors of initial effects could not move out to safe areas quickly enough to escape fatal radiation doses.

The feasible moves in Atlanta were limited to those near but not in the 5 psi area, the fire area and the fallout area. Rapid movement on foot was necessary. Persons outside the 5 psi area but within the 1000 roentgen-per-hour radiation area needed immediate movement.

Implications of Case Study Results

Inter-shelter movement was required notably in areas which experienced initial weapons effects (blast, fire and early arrival of heavy fallout). Fallout radiation on shelters with protection factors of 20 or more would not have endangered occupants, but would have been a hazard to those moving to escape fire. In some cases, it would have been better to stay in shelter and fight the fire.

Advance knowledge of escape routes from fire seemed important, as was having an EOC verify, if possible, the safety and passability of these routes. Information as to the location of low radiation areas could also be important.

The major decisions involved what to do if radiation existed and fires were burning in the area of the shelter. In the cases studied, "go-time" decisions were not required, and few public fallout shelters were available as secondary sites. In most cases, there was little or no time to coordinate vehicle use, although vehicles parked close to shelters being evacuated might have been used. Table 2 summarizes the results of the case studies, which were oriented to survival moves and not to later moves for other purposes.

At least one attack in each community required movement decisions. The MC attack on Whatcom County produced no fallout problem, but mass fires would have required a knowledge of escape routes and their conditions. Guidance from an EOC would have been highly important.

In the OAP attack on Atlanta, the movement to avoid radiation would have to have been conducted rapidly and effectively, and outside help would have been more important than in Whatcom County.

Des Moines suffered severe damage in the OAP attack, and movement would have been of little benefit, particularly with no EOC to aid in decisions. Shelter managers would have had to determine the ability of their shelters to withstand fire.

TABLE 2

Summary of Results of the Case Studies

Community and (Attack)	Peak Population*	Survivors of the Initial Effects	Number of People Moved	Additional Survivors Added by Remedial Moves
Whatcom County (MC)	43,000	27,108	27,108 (including 1,570 who could wait 8 hours)	1,000 to 5,000
Des Moines (OAP)	266,000	10,300	5,420	600
Atlanta (OAP)	1,860,000	1,100,000	105,000	70,000

*Prediction of survivors in Atlanta was performed on peak/peak population basis, i.e., the greater of the day or night populations were chosen for each SLA. The results above, therefore, are given for 1,860,000 people in contrast to the true residential population of about 1,200,000.

VII MOVEMENT ALTERNATIVES AND THEIR EFFECTIVENESS

Based on the foregoing analysis, four alternatives were developed to provide movement capability. They include certain of these elements:

1. In-shelter instructions and devices for evaluation of the situation.

2. In-shelter guides to evaluate alternative movements or on-site countermeasures.

3. Instructions in shelters and EOCs to assist in planning and conducting movements.

4. Means of obtaining information and assistance from an EOC or other coordination centers.

5. Guidance and training in all aspects of movement for CD officials at local levels.

No special vehicles or special police forces are included in the suggested alternatives, but all regular and auxiliary police should be familiar with methods for assisting in movement of large groups.

Costs of the alternatives have been related to the following levels of CD expenditure:

Level A -- CD expenditures at the current rate, providing an estimated $30 million a year for emergency operations programs.

Level B -- CD budget increased to $600 million per year to implement a full fallout shelter program, providing $60 to $100 million for emergency operations programs.

Level C -- CD budget increased to $4-5 billion per year to implement a blast shelter program in the 100 largest cities, providing $150-$200 million for emergency operations programs.

Alternatives

Table 3 summarizes the four alternatives and the annual costs of each.

TABLE 3

Alternative Programs

	A_1 System	A_2 System	B_1 System	B_2 System
Actions	Preparation of Handbook	A_1 System plus	A_2 System plus	B_1 System and
	Preparation of Appendix to Chapter D.4 of Federal Civil Defense Guide	Distribution of Handbook and Chart of Hazards to Occupancy in 2000 EOCs and 200,000 marked shelters.	Two days' training for two members of 2000 EOC staffs at $150 per person.	Preparation and distribution of maps and charts containing data specific to each shelter (at $30/ shelter).
		Low-cost city and county maps	Distribution of 200,000 shelter kits (at $5 each) containing: Wet-dry bulb thermometers, Carbon monoxide indicator, Megaphone Marker Strips	
Annual System Costs		$80,000	$320,000	$1,200,000
Total Costs over 5 years		$400,000	$2,000,000	$8,000,000

No cost was determined for a level C alternative. Since it would be for a blast shelter program, fewer movements would be required. For those in blast shelters who might require movement because of flood, ventilation failure, or other hazards, however, level B aids and training would be effective. Increased funds would permit purchase of equipment which would be useful to the Shelter Manager in performing this function.

Effectiveness of Alternative Programs

The number of people affected by movement depends upon the type of attack and the shelter status of the population. In the three case studies, large numbers of people required movement in at least one attack environment.

Based on studies of a nationwide attack with a full fallout shelter program, at least 14.5 per cent of the preattack population would require movement decisions and actions. While other attack patterns might result in different numbers of people being affected, any attack in urban areas apparently will mean that a considerable portion of the population will require movement advice, decisions, and/or related assistance.

Despite limitations -- the ability of the EOC to communicate information, the skill of the individual decision-maker, possible future emergencies, the availability of safe transportation -- the survival chances of large segments of the population may be significantly improved by development of contingency movement doctrine and guidance materials, and by training appropriate EOC personnel and shelter managers in their use. If only 10 per cent of those in the 1-5 psi area who survive the attack need movement decisions, guidance or assistance, three million persons would be affected.

The results of cost effectiveness comparisons among civil defense systems depends upon attack assumptions and the assumed capabilities of these systems. The type of attack is important when urban areas suffer direct nuclear effects, because a small but significant proportion of the population would benefit from remedial movement; and a low-cost movement capability would increase the probability of assistance being provided in such cases. Changes in capabilities of other functions are important because they will affect the need for movement. Construction of blast shelters or provision of increased fire protection, for instance, would reduce the instances in which movement would have to be considered.

VIII CONCLUSIONS

The study has led to the following conclusions:

1. Under certain attack conditions, the movement of large numbers of shelter occupants within urban areas will be important and feasible.

2. Decision-makers in a shelter must be able to evaluate the situation and to identify and determine possible on-site countermeasures.

3. Correct movement decisions, where the course of action is not apparent, will depend upon information about secondary sites and routes. Such information is much more likely to be available if an EOC or coordination center exists and can systematically collect and disseminate such information according to a plan.

4. In many cases, decisions in a shelter or an EOC will have to be made with incomplete information. Decisions about movement in the presence of fallout will be particularly difficult because of inaccuracies in estimating the dose received during movement.

5. Instructions should be available in the shelters for the initiation and control of movement, to prevent delays in loading and en route to the secondary shelter. Information from the EOC to the shelter will increase significantly the effectiveness of movement decision-making and planning.

6. The ability to communicate information from the EOC to shelter will improve significantly the effectiveness of remedial movement decision-making and planning.

7. An operating system which will increase the probability of correct movement decisions can be provided at relatively low cost.

8. Movement plans should be based on the utilization of existing vehicles and traffic control personnel, rather than on an organization that has been specially developed for this purpose.

9. The cost effectiveness of remedial movement has little value unless related to the complete civil defense operating and support system.

10. This study has indicated an area for investigation which is much broader than remedial movement. A capability is indicated at the EOC and at the Fallout Shelter for planning and conducting emergency operations to meet a range of possible contingencies.

IX IMPLICATIONS OF REMEDIAL MOVEMENT PROGRAM

A remedial movement program involves these implications:

1. No public involvement and support should be required to establish the recommended movement capability; it requires no new personnel for emergency operations and only minor additions to the equipment currently provided to public shelters.

2. The impact of the movement measures on civil defense systems lies mainly in training. Shelter managers and EOC analysts especially would have to become familiar with the handbook. Any provision for movement implies that the RADEF system is capable of estimating probable dose during movement. Since instruments and monitoring methods are inexact, RADEF personnel should be trained to estimate the accuracy of the dose reported. EOC staffs must insure that information about hazards, status of roads and possible relocation sites is disseminated when moves are likely. Police training should include techniques for control of masses of people moving on foot.

3. Remedial movement will be primarily a local responsibility. State governments, however, should encourage its inclusion in mutual assistance agreements between political subdivisions.

4. Potential military support depends on the availability of military personnel and the attack's effects. If available, military personnel and equipment would be useful in clearing movement routes and providing vehicular transportation. Requests for this type of assistance should be made by the EOC, which would know the availability, quantity, type and location of these resources. The shelter manager, however, should also be familiar with the military resources and authorities nearest his shelter so that he may request assistance directly if he is unable to communicate with his EOC. Individual reservists who are part of the sheltered population would be available to the shelter manager to assist in this and other tasks for which they might be qualified. Military personnel might also be used as escorts.

5. Implementation of a remedial movement program seems highly probable. Shelter supplies are installed regularly and need only be augmented by the movement guidance material and devices. The proposed training merely supplements training of local officials and other personnel already active in the civil defense program.